

How Tuberculosis Spreads in a Rural Community*

JEAN DOWNES

Milbank Memorial Fund, New York, N. Y.

IT is a well established fact that human aggregation greatly facilitates the spread of diseases like tuberculosis which are transmitted by way of the respiratory tract. Consequently, a rural area such as Cattaraugus County, N. Y., with its population about equally divided between two small urban areas and scattered farms and villages, offers an unusual opportunity for observing the spread of tuberculosis under fairly simple conditions.

As a part of an epidemiological study of tuberculous families in Cattaraugus County, a special effort has been made to learn how the disease is introduced into the families of that rural area, and what proportion of the total active cases occurring in the community is made up of cases due to contact within the family, and what due to extra-familial contact. This particular problem has been studied by obtaining detailed data for the families of all new active cases reported during 3½ years, January, 1932, to July 1, 1935. Data on the following points were secured through visits to the home and interviews with patients in the sanatorium by an investigator especially trained for this type of work.

1. Date of birth was secured for each member of the family or household, date of death, cause of death, and place of death for any member who had died. This information was secured also for persons other than family members, who had lived in the household 3 months or longer.

2. A history of chronic conditions was obtained for each member of the family and other household members. Such conditions as bronchitis, chronic cough, asthma, and pleurisy, were asked about especially. Dates as to time and duration were stated for each condition.

3. A detailed history of contact with tuberculosis both within the family and outside was secured for each case. The dates, or period, of contact were noted and the intimacy of contact described in detail.

4. A history of symptoms was secured for all cases of tuberculosis in each family and for any other member of the family who had had symptoms.

5. Serial X-ray examinations were secured for as many members of the families as possible.

6. A family history was recorded for the husband and for the wife in each family. This consisted of the same information described for the tuberculous families as in (1) to (4) for the brothers and sisters and parents of both husband and wife.

It is believed that the data obtained

* Read at a Joint Session of the Public Health Nursing and Epidemiology Sections of the American Public Health Association at the Sixty-fourth Annual Meeting in Milwaukee, Wis., October 9, 1935.

from these investigations give a clear picture of the family in respect to tuberculosis. The history of chronic conditions among members of the family or household and data concerning cause of death and age at death minimize the possibility of missed cases in the family as sources of infection for the first known case.

For each active case of tuberculosis the history of contact within the family and outside was secured in great detail and with the utmost care because of its importance in tracing the source of infection. Cases outside the family given as contacts of a case in the family being studied were investigated, either through the records of the County Department of Health or through correspondence and visits, to determine whether or not the possible source was a bona fide case of tuberculosis with a positive sputum. If the information concerning the extra-familial contact was inadequate and there was no case of tuberculosis in the home, the source of infection was classified as unknown.

Even though the history of extra-familial contact is secured with the greatest care, the question may be raised as to the validity of attaching significance to a known extra-familial contact as the source of important infection when there may be chances of repeated doses of tubercle bacilli through ordinary casual contact in the community. It seems safe to assume that in the rural area under consideration, the chances of encountering repeated doses of tubercle bacilli through casual contact in the community are at a minimum.* Special surveys have revealed a low rate of tuberculous infection. In 1930, only 7 per cent of

453 children aged 5-19, attending one-room schools in 18 rural towns, had a positive reaction to the intracutaneous test with 1 mg. of Old Tuberculin; 13 per cent of 650 children attending village schools in the same areas had a positive reaction; and 17 per cent of 439 children attending high school and grade school in an urban area of 9,000 population was positive to tuberculin. In addition, 529 persons from 20 to 69 years of age drawn from one village and the surrounding countryside were given the tuberculin test, and an average of 56 per cent showed a positive reaction. The proportion of children and adults from these groups showing by X-ray either calcified lesions or fibrosis was extremely low.

SOURCES OF INFECTION OF ACTIVE CASES OF TUBERCULOSIS IN THE COMMUNITY

The families of the total 105 new active cases of tuberculosis reported or discovered during the period January, 1932-July 1, 1935, were investigated according to the procedure outlined above. In only 34 per cent was there evidence of familial contact as the source; for approximately 40 per cent the source of infection was unknown. These persons either knew of no contact, familial or extra-familial, with the disease, or were classified as unknown because of inadequate proof of contact with an infectious case. Careful examination of the information obtained from the family concerning causes of death and chronic illnesses among the present and the past generation, and examination of the clinic records for family contacts have led to the conclusion that the family as a source of infection for all of the cases classed as unknown can safely be excluded. This leads to the conclusion that approximately 66 per cent of the total incidence of tuberculosis in this community is made up of cases in which the source of infection was outside the family. Thus

* The chances of acquiring tuberculosis in Cattaraugus County through tuberculous cattle or milk seem slight. Cattle in the county have been tuberculin tested routinely since 1923. The rate of positive reactors has varied from approximately 5 per cent in 1923, to 0.85 per cent of those tested in 1930.

extra-familial contact is undoubtedly a more important factor in the spread of tuberculosis in a rural area than has been generally believed.*

Analysis of the 63 cases where the source of infection is known shows that tuberculosis has been acquired chiefly through contact in the small centers of life of the rural population, namely, the family, the factories and other work centers, and the schools.† Tuberculosis was introduced into the family also through association with a neighboring family in which there was active disease, through contact among intimate friends, or by a boarder who had tuberculosis and was living temporarily with the family.

THE SPREAD OF TUBERCULOSIS WITHIN THE FAMILY

Since the family contact makes an important contribution to the total incidence of tuberculous disease in the community, it is of interest to consider the spread within the family. This can be shown most strikingly by the incidence of secondary cases with clinical symptoms among 334 contacts in a group of 83 families carefully observed over a period of years.‡ The primary case in each of the 83 families was one of active adult pulmonary tuberculosis and was selected from the total active cases which were reported during the period 1923-1930. The family contacts were observed from 3.5 to 12 years, with an average of 7.2 years of observation after the onset of the primary case.

* Myers, in discussing tuberculosis as a family disease, notes the fact that the disease is sometimes introduced into the family through contact with tuberculosis outside the family.¹

† Brachman, in an analysis of a tuberculin survey among 35,000 students in Detroit, found more tuberculosis in the high school age group in one school in the city. His conclusion was that perhaps one or more students in that particular school were infecting others.²

‡ The procedure for investigating the 83 families was identical with that described for the families of the 105 new active cases reported during the period January, 1932-July 1, 1935.

Twenty-eight cases of active tuberculosis with clinical symptoms occurred among the 334 contacts in the 83 families,* an average rate of incidence of secondary cases of 1.1 per 100 person-years.† A comparison of this rate with the average annual incidence of active tuberculosis by age for the total population of Cattaraugus County shows that the risk of contracting serious tuberculosis was 13 times greater for all family contacts than for persons in the community at large, with an even greater risk for persons under 20 years of age exposed to contagion in the family.

Undoubtedly, the members of tuberculous families have a definitely higher personal risk of contracting the disease than other individuals in the community; nevertheless, the data concerning the nature of the total community incidence seem to indicate that for every active case resulting from a familial contact there are 2 in the community as a result of extra-familial contact. The risk for the general population is less because that particular universe is many times greater than that formed by the family, but the spread of serious tuberculosis from an infectious case into the community at large is at least equally as great as in the family.

The age incidence of secondary cases

* The 28 secondary cases of tuberculosis evidenced definite activity with clinical symptoms. Nineteen were classed as adult pulmonary tuberculosis; 12 of the 19 were known to have positive sputum. There were 4 cases of tuberculous meningitis, 3 cases of tuberculous osteomyelitis, 1 case of tuberculosis of the kidney, and 1 case of tuberculosis of the cervical lymph nodes. Fourteen, or 50 per cent, of the 28 patients died of tuberculosis within the period of observation.

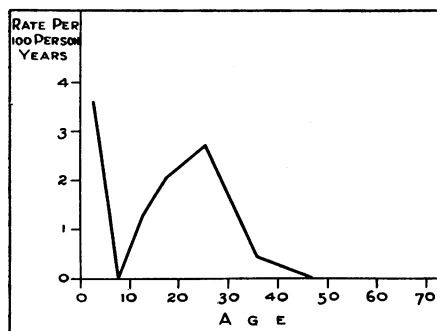
† The method of using the contacts as a population base was to consider each year of life of the exposed persons as a unit and the total population or person-years derived in this manner represent years of life after the factor of exposure to familial tuberculosis has been introduced. Person-years for the contacts were counted from the onset of the primary case to July 1, 1934. The method is explained in greater detail in the following article: Downes, Jean: A Study of the Risk of Attack Among Contacts in Tuberculous Families in a Rural Area, *The American Journal of Hygiene*, November, 1935.

with clinical symptoms, as shown in Figure I and Table I, is of importance

TABLE I
AGE INCIDENCE OF SECONDARY CASES OF ACTIVE
TUBERCULOSIS IN 83 TUBERCULOUS
FAMILIES, CATTARAUGUS
COUNTY

Age Group	Rate per 100 Person- Years	Number of Secondary Cases of Active Tu- berculosis	Number of Per- son-Years Observed at Each Age
0- 4.....	3.6	5	137
5- 9.....	0	0	304
10-14.....	1.3	4	309
15-19.....	2.0	6	301
20-29.....	2.7	12	441
30-39.....	0.4	1	279
40-49.....	0	0	279
50-59.....	0	0	234
60+.....	0	0	189

FIGURE I



because it indicates the ages at which tuberculosis among family contacts occurs most frequently. At ages 0-4 the incidence is 3.6 per 100 person-years, the highest found in any age group. At ages 5-9 the rate is zero, then rises to 1.3 at 10-14 years. The frequency of cases in the next age period increases rapidly and reaches a second peak at ages 20-29 with a rate of 2.7 per 100 person-years. The high incidence of tuberculosis among infants and children of preschool age in tuberculous families is a well known fact. The tendency for children who have had intimate exposure to tuberculosis

to develop the disease at the teen ages is also generally recognized. But the second peak of incidence of active disease at ages 20-29 is of especial significance since insufficient emphasis has been placed upon the periodic examination of family contacts over 19 years of age, and these young adults are frequently establishing new family units which offer the possibility of a further spread of tuberculosis.

THE SPREAD OF TUBERCULOSIS THROUGH EXTRA-FAMILIAL CONTACT

Since a large proportion of the active cases believed to be due to extra-familial contact with tuberculosis are unknown as to the type of contact, that is, work, school, neighbors or other friends, it is difficult to rank the various types as to importance with any degree of certainty. However, for those cases where the source of infection is known, work contact seems most important in this rural area. Contact among school friends, neighbors and other friends as a means of spread of tuberculosis occurred with about equal frequency, but these types seem to be slightly less important as a source than work contacts.

In Cattaraugus County there are a number of small industries in various villages which have definite occupational hazards to health. These are cutlery factories and monument works. It is recognized that grinding and work with granite offer special hazards to the lungs, and the breakdown of lung tissue due to silicosis would produce a favorable condition for the lighting up of an old tuberculous process; nevertheless, it is believed that there has been a spread of tuberculosis from contact in some of these plants. For example, in a small cutlery factory where an average of 30 men have been employed as grinders throughout the past 13 years, 17 cases of known active pulmonary tuberculosis with 9 deaths

have occurred during that time. On the other hand, in a cutlery factory in a nearby village, where hygienic measures in regard to spitting and general cleanliness were put into practice 10 years ago, only 1 case of active tuberculosis has been known among the grinders within that period.

The possibilities of the spread of tuberculosis by means of extra-familial contact of other sorts may best be illustrated by showing examples. Figure II shows the spread of tuberculosis among neighboring families. Individuals in the family are indicated on the chart as males or females by the sex signs used in genetic charts. Age is recorded for each individual in the family as at the time of onset of the active case. Family A consists of husband, wife, and 1 child, a daughter. The wife developed pulmonary tuberculosis with positive sputum at age 23. The daughter was 7 years of age when exposed to the mother. Family B lived in the house next to Family A. The wife in Family A, the primary case, was especially interested in the twin girls aged 13 in Family B, and they visited her very often while she was ill. One of the twins died of tuberculous meningitis within a year after exposure to the

FIGURE II

SPREAD OF TUBERCULOSIS
AMONG NEIGHBORS

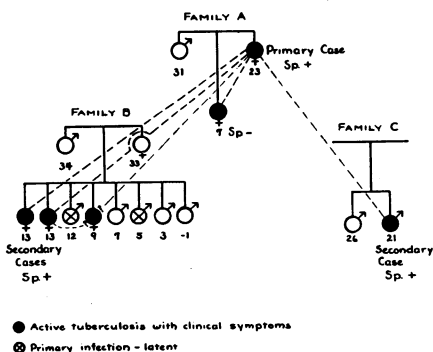
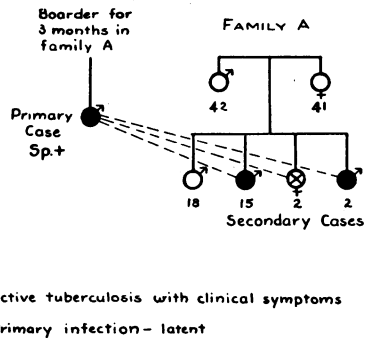


FIGURE III

SPREAD OF TUBERCULOSIS FROM BOARDER
IN HOME OF FAMILY A



primary case, and the other developed adult pulmonary tuberculosis with a positive sputum. The 9 year old daughter in Family B who developed tuberculosis was also exposed to the primary case in Family A, but it is questionable whether or not the exposure to her own sister was more important.

Family C consists of 2 men who were distant cousins of the husband in Family A. Both parents were dead but neither died of tuberculosis. The male aged 21 who developed tuberculosis was in the home of Family A when he had an attack of influenza and the wife in the family nursed him for 3 weeks. At that time she was believed to have had tuberculosis for at least a year. Two years later he developed pulmonary tuberculosis with positive sputum. All of the contacts in the 3 families have been X-rayed periodically and there is no other tuberculosis in these families except as indicated on the chart.

Figure III shows the spread of tuberculosis from a boarder who had positive sputum and lived 3 months in the home of Family A. Two of the children, one a male aged 15 and the other a male aged 2, developed tuber-

culous osteomyelitis a year after the boarder left the home. The twin sister aged 2 had a lesion of primary infection demonstrable by X-ray. All other contacts have been examined periodically with negative findings. The possibility of tuberculous cattle or milk as a source was investigated with negative results.

FIGURE IV
SPREAD OF TUBERCULOSIS
AMONG SCHOOL FRIENDS

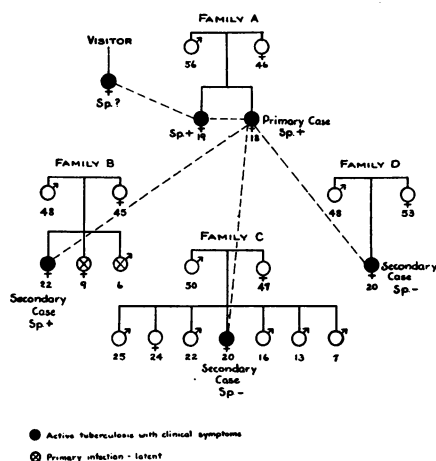


Figure IV shows the spread of tuberculosis among school friends. The contact of the secondary cases in families B, C, and D, with the positive sputum primary case in Family A occurred during the senior year at high school. It is believed that tuberculosis was introduced into Family A by an adult with chronic tuberculosis who visited frequently in the home for periods varying from 3 days to 2 weeks during 4 consecutive years previous to the onset of tuberculosis in the 19 year old daughter. One year later the younger sister developed tuberculosis at the age of 18. She continued to attend school with occasional absences throughout 10 months of her illness. The secondary case in Family C and the one in Family D were her most intimate friends both

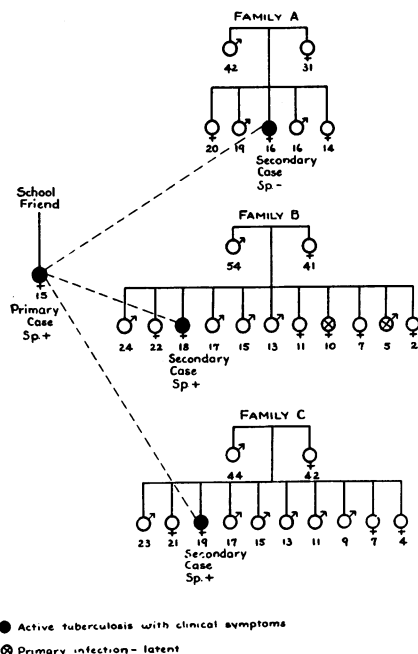
in school and outside of school. The case in Family B was a contact in school only. These secondary cases developed active adult pulmonary tuberculosis within a period of 4 years after exposure to the primary case in Family A. All of the contacts in these families except the parents in Family A have been examined, and there was no other tuberculosis found except that indicated on the chart. This chart is a striking illustration of the fact that as a result of one case in Family A, tuberculosis has been introduced into 3 other families in the same community with further possibilities of spread among the family contacts.

Figure V is similar to Figure IV in that it demonstrates the spread of tuberculosis among school friends but in another part of the county. All of the secondary cases shown in Figure V developed tuberculosis within a period after exposure to the primary case similar to that found for the cases in Figure IV, namely, from 1 to 4 years. Families A, B, and C have been under supervision for a period of from 5 to 10 years. Though all of the contact members of families B and C have acquired infection demonstrable by the tuberculin test, and 2 members of Family B have a lesion of primary infection visible by chest X-ray, no case of active tuberculosis with clinical symptoms has developed among them. The 3 cases spent most of the period of infectiousness in sanatoria. All available evidence indicates that the secondary cases in families A, B, and C were actually the first cases to occur in these families and that the source of infection was an extra-familial contact.

From the data presented it is evident that both familial and extra-familial contact are important factors in the spread of tuberculosis in a rural community. Administrative procedures for the control of tuberculosis are planned mainly around the tuberculous family,

FIGURE V

SPREAD OF TUBERCULOSIS AMONG SCHOOL FRIENDS



but it seems obvious that to meet the community problem adequately some emphasis should be placed upon the examination and supervision of the extra-familial contact. The data indicate that the spread of serious disease from the tuberculous family into the larger universe, the community, is at least as great as within the family. The question is how to select from the community those individuals who have had a relatively intimate exposure to tuberculosis.

An attempt to meet the problem is being made in Cattaraugus County. During the past year and a half histories similar to those described in this study have been secured for all new active cases of tuberculosis diagnosed or reported. The purpose of

the history is explained to each case as a part of the program of preventive work. If the active case is found to have positive sputum, the more intimate extra-familial contacts are asked to have a clinic examination; if the sputum is negative no extra-familial contacts are examined unless the source of infection for the reported case is being sought among them, and then only after the family as a source has been eliminated. The intimacy of contact, the results of the chest X-ray and tuberculin test, and the age of the individual are the criteria used to determine the necessity of further periodic follow-up and examination for the extra-familial contacts.

The response to this program of preventive work in tuberculosis has been most favorable both on the part of the individuals who have tuberculosis and the contacts outside of the family who have been asked to have a clinic examination. None of the extra-familial contacts who have been asked to have a clinic examination has refused to do so. However, the full effectiveness of such a program cannot be measured until more data are available.

REFERENCES

1. Myers, J. A. Tuberculosis—A Family Disease, *J. Outdoor Life*, XXVII, 10 (Oct.), 1930.
2. Brachman, D. S. Recent Observations in Community Prevention of Tuberculosis—Observations on 35,000 Students, *J. Michigan State Med. Socy.*, Nov., 1932.

Acknowledgments are made to the Cattaraugus County Department of Health, especially to Dr. John H. Korn, Director of the Bureau of Tuberculosis, who has cooperated in making the study and to Mae P. Duffy, who was responsible for the collection of the information from the tuberculous families. Acknowledgments are made also especially to the families in Cattaraugus County who have so generously participated in making the study possible.